while the cyclone was yet at the Windward Islands, about 1200 miles distant.

A sudden and abnormal rise of the barometer thus constitutes as important a warning to a navigator as a similar fall, or a band of cirrus-cloud, only to be able to make effective use of this danger-signal he ought accurately to know the normal height of the barometer where he is, and at the time of year. The author shows how this may be done in Part I., where he has constructed charts, based on a large series of observations in the northern hemisphere, showing not only the curves of mean annual pressure, but also those which represent the coefficient of annual inequality. From a simple equation involving these two elements, the normal pressure at any time and place can be approximately reckoned, and hence the amount of abnormality determined.

The author next applies the cyclone theory in explanation of the various inequalities of barometric pressure, which are observed on the same latitude in different longitudes. These inequalities he considers to be mainly dependent on the deviations of the mean temperature (annual or monthly) from the mean of all longitudes, which he gives in a tabular form for every fifth degree of latitude and every tenth degree of longitude in the northern hemisphere, by means of interpolation from the observations discussed in Part I. From these tables it appears that in addition to, and superimposed upon, the general system of two polar cyclones due to the normal differences of temperature between the Equator and the Poles, we have throughout the year, and more especially in the winter, the conditions for the existence of a large fixed warm-centred cyclone in the North Atlantic, with its centre near Iceland. The barometric pressure should consequently be lower here than the mean of the latitude taken round the globe. That this is the case is well-known, and also that the prevalence of south-west winds in these islands is due to our generally lying on the south-east edge of this nearly perpetual cyclone. A similar cyclone similarly produced lies in the North Pacific.

Two corresponding regions of abnormally low temperature lie one on the east side of Asia, and the other on the east side of America, which, according to the author's theory, should give rise to cyclones with cold centres. As a matter of fact, however, these conditions are found to be completely reversed; the pressure being above the average, especially in winter, when the temperature-gradients are steeper, and therefore, according to the author's views, the cyclonic conditions should be more developed; while the motion of the air at the surface is anticyclonic, and outwards from the region of greatest relative cold.

The least satisfactory part of the author's work is that which relates to these cyclones with cold centres. Their non-existence in the progressive form is admitted, and where they should occur according to theory in a stationary form, they are notably absent, except in the two circumpolar cyclones. It is possible, however, that they may be identified, though in a modified form, and lacking the central barometric depression *at the earth's surface*, with what are termed "winter anticyclones," which usually coincide with areas of great cold, and which, while they exhibit at the earth's surface an anticyclonic outflow of air, are fed above a certain level by a cyclonic inflow.

Finally, as regards rainfall, which is an almost unfailing accompaniment of cyclones, the author, while admitting its assistance in helping to maintain a cyclone when once started, by the forces which operate whenever vapour is condensed, is strongly opposed to its being a *primary* source of energy, and cites in favour of this notion the following conclusion, arrived at by Prof. Loomis, after a careful study of the U.S. Signal Service charts. "Rainfall is not essential to the formation of areas of low barometer, and is not the principal cause of their formation or of their progressive motion."

The last chapter of the author's work which relates to tornadoes, waterspouts, and hailstorms, has already been referred to in a special article in NATURE, and it only remains for us to observe in connection therewith, that while tornadoes differ specifically in many respects from cyclones, the condition of the atmosphere in the latter is eminently favourable to their production. To this circumstance, according to Ferrel, may be attributed the occurrence of sudden blasts of tornado violence in the middle of cyclones, accompanied by a rapid oscillation of the wind-vane. It is these sudden gusts which do the main damage in such cases, since, as might be expected, the velocity of the wind increases *per saltum* where the gyrations of the tornado and the cyclone coincide in direction. They are found to occur more on the cold or clearing-up side of a cyclone, which Ferrel explains to be due to the cold upper strata overlapping the warmer central part of the storm, and thus promoting a condition of vertical instability of equilibrium in which tornadoes are generated with facility. Viewing the work as a whole, Mr. Ferrel may be congratulated on having presented to the world a memoir of such luminous research as well as practical utility. When we compare it with the numerous other crude treatises and hypotheses evolved during the past half-century on the same subject, which have not only brought the science of meteorology into ridicule, but encumbered our libraries, we feel a deep sense of relief at finding the question dealt with by a mathematician of more than ordinary ability, and one who does not shrink from tackling the real difficulties of the subject. He has for some time been known by his writings on hydrodynamical questions of great importance, especially those applying to the general motions of the atmosphere. The present work will go far towards placing him in the very front rank of physical and theoretical meteorologists. The deductive method has been fairly applied throughout to the equations of motion, and its success will do much towards counteracting the too prevalent tendency at the present time to induct from every solitary phenomenon, or experiment, to some otherwise baseless hypothesis. If the author has not accounted for all the peculiarities of cyclones, he has at least shown that the views entertained by the leading meteorologists regarding their formation, characteristics, and general movements accord with their mechanical theory, and that the sources of energy ordinarily assumed to act, such as heat, gravitation, and terrestrial rotation, are sufficient, without having recourse to any wild hypothesis founded on some unknown function of electricity. The valuable practical hints and suggested modifications of existing rules will do much to avert disasters at sea, the main purpose, doubtless, for which the work was designed, while its thoroughness and comprehensive character will materially help to advance our knowledge of a meteor, which in one form or another comprises almost every condition of the atmosphere included under the term "weather." E. DOUGLAS ARCHIBALD

ON PHOTOGRAPHS OF THE SPECTRA OF THE NEBULA IN ORION[1]

FOR about eighteen months I have been giving attention to the nebula in Orion with two objects in view, first to ascertain whether any changes are taking place in that body by making a series of photographs to be compared in the future with a similar series; and second, to photograph the spectrum of the nebula in various parts so as to see whether any new lines could be found, and also whether the composition is uniform throughout.

As to the first of these objects I have recently suc-

[1] Read before the National Academy of Sciences, April, 1882, at Washington, U.S., by Henry Draper, M.D. Communicated by the author.

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ceeded in taking a very fine and extensive photograph of the nebula containing most of the delicate outlying parts which were not in my earlier photographs. This is in the hands of the photolithographer now and will shortly be published. The experiments have been very difficult because an exposure of more than two hours in the telescope has been necessary, and an exceedingly minute motion of the stars relative to the sensitive plate will become apparent on account of the high magnifying power (180) employed.

In carrying out the second object two contrivances have been used; first, a direct-vision prism in the cone of rays from the objective before they had reached a focus, and second the two-prism spectroscope with which I have taken photographs of stellar spectra for some years past.

During the month of March I have made two good photographs with each of these arrangements. Those with the direct-vision prism, without a slit, have of course demanded that the image should be kept stationary on the sensitive plate throughout the exposure, viz. two hours, and they are as difficult to get as good photographs of the nebula itself. On the contrary, those obtained with the slit spectroscope do not require the same steadfast attention.

The results derived from these photographs are interesting partly from what they show and partly from what they promise in the future. A number of photographs, under various conditions, will be needed for the full elucidation of the subject.

The most striking feature is perhaps the discovery of two condensed portions of the nebula just preceding the trapezium, which give a continuous spectrum. At those places there is either gas under great pressure or liquid or solid. I have not been able to detect any stars of sufficient magnitude in these portions to produce this effect either in my photographs of the nebula or in any of the well-known drawings of this object. It seems to me also that the photographs show evidence of continuous spectrum in other parts of the nebula. In these respects the conclusions arrived at by Lord Rosse in his memoir (*Phil Trans.* Royal Society, June 20, 1867, p. 70) are to a certain extent borne out.

The hydrogen line near G, wave-length 4340, is strong and sharply defined; that at *h*, wave-length 4101, is more delicate, and there are faint traces of other lines in the violet. Among these lines there is one point of difference, especially well shown in a photograph where the slit was placed in a north and south direction across the trapezium; the Hγ line, λ 4340, is of the same length as the slit, and where it intersects the spectrum of the trapezium stars, a duplication of effect is visible. If this is not due to flickering motion in the atmosphere, it would indicate that hydrogen gas was present even between the eye and the trapezium. I think the same is true of the Hδ line, λ 4101. But in the case of two other faint lines in this vicinity, I think the lines are not of the length of the slit, one being quite short and the other discontinuous. If this observation should be confirmed by future photographs of greater strength, it might point to a non-homogeneous constitution of the nebula, though differences of intrinsic brightness would require to be eliminated.

The April number of the *American Journal of Science* contains an account of a photograph of the spectrum of this nebula taken by Dr. Huggins. I have not found the line at λ 3730, of which he speaks, though I have other lines which he does not appear to have photographed. This may be due to the fact that he had placed his slit on a different region of the nebula, or to his employment of a reflector and Iceland spar prism, or to the use of a different sensitive preparation. Nevertheless, my reference spectrum extends beyond the region in question.

As illustraring the delicacy of working required in this research, it may be mentioned that in one of these photographs the spectrum of a star of the tenth magnitude is easily discerned. It is only a short time since it was considered a feat to get the image of a ninth magnitude star, and now the light of a star of one magnitude less may be photographed, even when dispersed into a spectrum.

EPPING FOREST

ON Saturday last, May 6, the Queen declared free to the public the 5600 acres of open land to the north-east of London, known as Epping Forest. The history of the rescue of this magnificent tract, so long the favourite resort of London naturalists, has been told many times since the Corporation of London took up the question, and by their well-directed efforts not only checked the encroachment of rapacious land-owners, but restored to the people about 1000 acres of forest land that had been illegally inclosed. The total cost of this philanthropic movement may be estimated at nearly half a million of money, and the Corporation has deservedly earned the gratitude of all Londoners, and more especially of those lovers of nature who have for long been in the habit of regarding the Forest as a preserve from which they could obtain materials for their studies. It is a common complaint with our natural history students, that the open spaces around London are gradually being destroyed as the pressure of population necessitates increase of buildings in the suburbs, so that the preservation of this large area is really a matter of considerable scientific importance, and as such will be regarded with satisfaction by the readers of NATURE. Fortunately for naturalists, the Act of Parliament declares that the woodland tract under consideration shall be kept as far as possible "in its natural aspect." There has thus been secured to the public at large, and to the metropolitan field naturalists, a recreation-ground of a quite peculiar character, and one which will be looked upon as a great boon by botanists, zoologists, and microscopists.

The value of Epping Forest, from our point of view, lies chiefly in its wildness; by far the greater portion is primitive woodland, which has been but little interfered with by man in comparison with the heaths and commons to the north, west, and south of London. Such an expanse requires little in the way of "improvement." The Conservators have acquired a power of dealing with one of the few surviving remnants of primæval Britain, and in the interests of that continually increasing class of the public who devote themselves to the various branches of out-door natural history, it is to be hoped that this authority will be exerted judiciously. We are disposed to believe that the requirements of the ordinary holiday-maker and of the field naturalist are in this case identical. To be able to roam through many miles of wild forest is as truly a pleasure and novelty to the former as it is a necessity to the latter. From whichever side we view the question of the conservation of the forest, any attempts to destroy its natural features cannot but be deprecated, and in view of the fate of so many of the open spaces round London, this position cannot be too strongly emphasised by those to whom the preservation of our rapidly-disappearing natural history resorts is a matter of importance.

The problem of managing a tract of country which consists of a large proportion of primitive forest and a smaller proportion of land formerly under cultivation, so as to comply with the conditions of the Act and with the requirements of all classes of the public, is not so difficult as might appear at first sight. It is not as though the interests of field-naturalists in any way clashed with those of the general public. We have here a wide expanse *pro delectatione populi*, which is to be distinguished and to be kept distinct from all other public spaces in the vicinity of the metropolis by virtue of its forestal wildness,

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